APPENDIX G: SUMMARY OF ALL SIGNIFICANT BASELINE INVENTORIES AND MONITORING IN SIERRA NEVADA PARKS

Current knowledge regarding past and present monitoring and important baseline inventory projects are summarized below for Sierra Nevada Network parks, organized by topic, then park (where appropriate). New information gathered as part of further datamining efforts will be added to future Monitoring Plans (Phase II and III).

Monitoring conducted by other agencies and organizations located throughout the Sierra Nevada (e.g. U.S. Forest Service) is summarized in Appendix H and briefly in Chapter 1 of the Sierra Nevada Network Phase II Monitoring Plan.

Park-based monitoring projects likely to have the most value to the network's vital signs monitoring program are those pertaining to resources identified as potential vital signs and having formal and well-documented protocols:

- Air quality (ozone, dry and wet deposition chemistry, particulate matter)
- Meteorology (weather and climate)
- Hydrology (USGS, NPS and Southern California Edison gaging stations)
- Water quality (associated with rivers, streams and lakes—only a few long-term sites)
- Fire effects (vegetation, fuels, water chemistry, wildlife)
- Fire regimes (seasonality, severity, areal extent, frequency of fires at landscape level)
- Meadows (species composition, residual biomass, pack stock use, repeat photography)
- Forest demography (USGS forest plots in Sequoia and Yosemite)
- Ozone (e.g. effects on yellow pine)
- Avifauna (Monitoring Avian Productivity and Survivorship)
- Amphibians (e.g. Mountain yellow-legged frog—repeat inventories of high-elevation lakes, frog restoration)

Following are a listing of principal past and present inventory and monitoring projects and programs among SIEN parks. Baseline inventories with potential value to the vital signs monitoring program, are included as well (and whose summaries may be of particular interest to the resource management "audience").

Project details and metadata, where available, are captured in SIEN's data documentation database (begun in 2003 and developed by SIEN staff). Additions to this database are ongoing (contact SIEN I&M staff).

Atmospheric

In the Sierra Nevada Network there are three (YOSE, SEQU, KICA) Class I air sheds and one Class II air shed (DEPO). According to the Clean Air Act and subsequent amendments, federal land mangers have responsibility to protect visibility, flora, fauna, waterbodies, and other resources that may be potentially affected by air pollution.

Class I parks in the SIEN network have a complex air monitoring program. Supported by national NPS Air Resources Division, these parks are included in several national networks measuring wet and dry deposition, ozone, visibility, mercury, particulate matter, and meteorology. The air resources programs strive to acquire high quality data, make information available to the public, and take the opportunity to participate in decisions being made by agencies regulating emissions.

Atmospheric monitoring in SIEN parks.

DEVILS POSTPILE	SEQUOIA & KINGS CANYON	YOSEMITE
Air Quality		
	15 sites monitor various parameters, including: • ozone • Precipitation chemistry • visibility	19 sites monitor various parameters, including: • ozone • Precipitation chemistry • visibility
Meteorology		
1 site: • RAWS (weather and fuel sticks)(removed from site 2004) • New meteorological station installed (Summer 2005)	14 sites—various parameters, including: • RAWS (weather and fuel sticks) • temperature • precipitation • solar radiation • relative humidity • windspeed/direction • solar radiation • snow water equivalent • snow depth	8+ sites—various parameters, including: • RAWS (weather and fuel sticks) • temperature • precipitation • solar radiation • gamma radiation • relative humidity • windspeed/direction • relative humidity • snow water equivalent • snow depth

Wildlife (Terrestrial and Aquatic)

Most long-term monitoring of wildlife (terrestrial and aquatic) has been conducted on bears (interactions/incidents with humans), birds, and a few selected groups and taxa with special status (mountain yellow-legged frog, Sierra Nevada bighorn sheep, California Spotted Owl).

Wildlife inventory projects are included in this appendix if considered important as "baseline" for future monitoring efforts (e.g. Grinnell Survey, amphibian and avian studies).

Invertebrates have generally been under-represented in inventory, monitoring, and other studies in Sierra Nevada Network parks.

Wildlife monitoring in SIEN parks.

DEVILS POSTPILE	SEQUOIA & KINGS CANYON	YOSEMITE
Multiple taxonomic groups		
	• Wildlife Observations Database	• Wildlife Observations Database • Annual Wildlife Reports • Grinnell Survey
Amphibians & Reptiles		
	• Salamanders-baseline inventory • Mountain yellow-legged frog • Western pond turtle	• Lentic fauna survey (vertebrate and invertebrate) • Salamanders-baseline inventory • Status of Amphibians • Yosemite toad • Mountain yellow-legged frog
Birds		
• Baseline Inventory • Monitoring Avian Productivity and Survivorship (MAPS) stations	• Baseline Inventory • MAPS stations • Breeding Bird Surveys • Christmas Bird Count • Peregrine Falcon • California Spotted Owl • Important Bird Areas	• Baseline Inventory • MAPS stations • Christmas Bird Count • Great Grey Owl • Peregrine Falcon • California Spotted Owl

DEVILS POSTPILE	SEQUOIA & KINGS CANYON	YOSEMITE
	• Brown-headed Cowbird	
Mammals		
	• Forest carnivores • Black bear • Sierra Nevada bighorn sheep • Bats • California ground squirrel • Yellow-bellied marmot • Small mammals (fire studies)	• Forest carnivores • Black bear • Sierra Nevada bighorn sheep • Bats • Mountain lion • Mule deer
Fishes		
• Population assessments	• Species composition, density, habitat variables • Little Kern golden trout	• Baseline survey • Lentic fauna survey
Invertebrates		
• Benthic macroinvertebrates • Meadow invertebrates	• Giant Sequoia forest invertebrates-baseline inventory • Bark beetles (fire studies/USGS)	• Lotic benthic invertebrates baseline survey • Lentic fauna survey (macroinvertebrates) • High-elevation meadow invertebrates • Macroinvertebrates – Merced River

Terrestrial Vegetation

Sequoia, Kings Canyon, and Yosemite National Parks have a rich history of vegetation-related inventories, research, and monitoring projects. Most long-term vegetation monitoring in these parks has been related to measuring effects of resource management programs (especially fire, exotic plant control and restoration), recreation (especially pack stock grazing), and air pollution (also described above). The USGS-Biological Resources Division also conducts long-term vegetation monitoring in Sequoia and Kings Canyon and Yosemite: forest demography across elevations is the longest term dataset. Vegetation plots for ozone damage are also included.

Aside from fire-effects plots established in 1992, Devils Postpile has not had staffing or resources to do long-term vegetation monitoring.

All parks have had vegetation inventories done that are of value as baseline data for long-term monitoring. These include vegetation maps, Natural Resource Inventories in the 1990s in Sequoia, Kings Canyon, and Yosemite (Graber et al. 1993), a vascular plant inventory in Devils Postpile (Arnett and Haultain 2004), and rare plant surveys for individual park units (Moore, P. 2005).

Restoration projects with associated monitoring (e.g. photopoints) are also included.

Vegetation monitoring in SIEN parks.

DEVILS POSTPILE	SEQUOIA & KINGS CANYON	YOSEMITE
Meadows, Wetlands, Riparian		
• Soda Springs meadow-restoration success	• Alpine meadows • Meadows (pack stock use-distribution and abundance of pack stock) • Meadows (pack stock effects-residual biomass, species composition, and trends in condition)	• Alpine meadows • Meadows (pack stock use) • Meadows (grazing effects-plant species inventory) • Pavillion Square meadow • Cooks meadow • Happy Isles fen • Eagle Creek streambank vegetation
Forest Demography		
	• Forest dynamics	• Forest dynamics • Ponderosa pine/mixed conifer forest
Alien invasive species		
• Inventory	• Inventory (trails and developed areas) • Recently burned area (in progress)	• Inventory (trails and developed areas) • Riparian (in progress)
Phenology		
	• Sequoiadendron giganteum • Pinus ponderosa • P. lambertiana • Abies concolor • Calocedrus decurrens • Quercus kelloggii	
Air Pollution Effects		
Pinus jeffreyi	• Baseline ozone effects (Pinus ponderosa, P. jeffreyi) • Ozone response (Pinus ponderosa, P. jeffreyi) • Ozone reponse (multiple species)	• Ozone response (Pinus ponderosa, P. jeffreyi) • Ozone reponse (multiple species)

DEVILS POSTPILE	SEQUOIA & KINGS CANYON	YOSEMITE
	• Physioecological response (Pinus jeffreyi)	
White Pine Blister Rust		
	• Five needle pines (Pinus lambertiana, P. monticola, P. albicaulis, P. balfouriana, P. flexilus)	• Five needle pines (Pinus lambertiana, P. monticola, P. albicaulis, , P. flexilus)
Vegetation Change		
	• Repeat photography (USGS-BRD)	

Fire

The parks' fire monitoring programs began in 1982 for Sequoia & Kings Canyon, 1978 for Yosemite and 1992 for Devils Postpile. The programs in Sequoia & Kings Canyon and Yosemite initially focused on monitoring weather and fire behavior, vegetation, and dead and down surface fuels in giant sequoia groves and other early experimental prescribed burns in mixed-conifer forests. Over time, the monitoring programs expanded to other vegetation communities as the prescribed fire programs progressed. In recent years, Sierra Nevada fire-monitoring programs have broadened to include additional vegetation, wildlife, water, and/or fire regime components. Devils Postpile does not currently have a Fire and Fuels Management Plan (NPS in progress), however, fire effects monitoring plots were established in association with a 1992 wildfire that burned approximately two-thirds of the monument.

Monitoring environmental and fire condition provides information to guide fire management strategies for both wildland and prescribed fires; such monitoring encompasses a wide variety of fire topics, including:

- environmental and fire conditions,
- fire effects on vegetation and fuels,
- mechanical fuels-treatment monitoring,
- fire effects on animals,
- fires effects on water, and
- fire regimes, restoration, baseline fire history

In addition to fire-related monitoring conducted by SIEN park staff, USGS-Western Ecological Research Center staff at both Sequoia and Kings Canyon and Yosemite Field Stations have contributed an inordinate amount of fire-related monitoring regarding SIEN parks and greater Sierra Nevada ecosystems. USGS projects in our parks are an integral part of NPS resource management information and decision-making.

Fire-related monitoring is summarized in the following table, below; it is described in greater detail in the Sequoia and Kings Canyon and Yosemite National Parks Fire and Fuel Management Plans (NPS 2003, 2004).

Fire-related monitoring in SIEN parks.

DEVILS POSTPILE	SEQUOIA & KINGS CANYON	YOSEMITE
Environmental and Fire Conditions		
	• weather • fire conditions (for wildland and prescribed fires) • burn severity • fire behavior	• weather • fire conditions (for wildland and prescribed fires) • burn severity • fire behavior
Fire Effects: Vegetation and Fuels		
• Post-burn (tree and seedling mortality, char/scorch, fuel loading, burn severity) • Repeat photography (1, 2, 5, 10, and 15 years post-burn) (Pre-burn conditions not measured due to wildfire.)	• Pre-burn (tree-shrub-herbaceous layer, dead-and-downed fuel) • Post-burn (tree and seedling mortality, char/scorch, fuel loading, burn severity) • Repeat photography (1, 2, 5, 10, and 15 years post-burn)	• Pre-burn (tree-shrub-herbaceous layer, dead-and-downed fuel) • Post-burn (tree and seedling mortality, char/scorch, fuel loading, burn severity) • Repeat photography (1, 2, 5, 10, and 15 years post-burn)
Mechanical Fuels Treatment Monitoring		
	• Effects of mechanical thinning (overstory, seedlings, shrubs, fuels, soil, nonnative plants, potential fire hazard) • Pre- and post-treatment data • Repeat photography	• Effects of mechanical thinning (overstory, seedlings, shrubs, fuels, soil, nonnative plants, potential fire hazard) • Pre- and post-treatment data • Repeat photography
Fire Effects on Wildlife		
	• Rodent populations (response to prescribed fire) • Other wildlife species	
Fire Effects on Water		
	• Hydrology	

DEVILS POSTPILE	SEQUOIA & KINGS CANYON	YOSEMITE
	• Hydrochemistry	
Fire Regime		
• Fire history/age structure	• Cumulative accomplishments • Restoration goals • Fire history/age structure	• Fire history/age structure • Mixed-conifer forest—natural reference conditions
USGS-Western Ecological Research Center Stations		
	• Fire Surrogate Study (13 sites established nationwide) • Fire hazard reduction treatments • Fuels, behavior • Birds and small mammals • Soils, forest floor • Bark-beetle • Pathogen infection (Heterobasidion annosum—fir) • Invasive annual grasses • Fire and grazing impacts on plant diversity and plant invasions	

Aquatic

Hydrologic and water chemistry monitoring is summarized in the following table, below. Detailed information describing activities in and around SIEN can be found in Appendix D.

Aquatic monitoring in SIEN parks.

DEVILS POSTPILE	SEQUOIA & KINGS CANYON	YOSEMITE
Hydrology		
• Middle Fork of the San Joaquin	• 12 active gaging stations (all located in the Kaweah River drainage) • 24 historic gaging stations	• 21 active gaging stations
Water Chemistry		
• Baseline water quality (12 sites within/near boundary) • Total coliform, *Escherichia coli*, minerals, inorganic chemical parameters • Drinking water (one site)	• Middle Fork of the Kaweah watershed studies (stream flow and chemistry, conductivity, nutrients, cations/anions) • Hydrologic Benchmark Site (long-term trends on the Marble Fork of the Kaweah) • Landscape scale prescribed-fire effects on watershed chemistry (East Fork of the Kaweah) • High-elevation lake water quality and atmospheric deposition (20 lakes) • Drinking water (thirteen sites, in frontcountry and wilderness)	• Hydrologic Benchmark Site (long-term trends on Merced River at Happy Isles) • High-elevation lake water quality and atmospheric deposition (9 lakes) • Drinking water (frontcountry and wilderness) • Water quality (Tioga Pass, Dana Meadows, Tuolumne Meadows)

Geologic and Physical Resources

For detailed information on monitoring of geology, geomorphology, physical cave resources and soils, infra (summary in table, below).

Geologic and physical resources monitoring in SIEN parks.

DEVILS POSTPILE	SEQUOIA & KINGS CANYON	YOSEMITE
Geology		
		• Baseline geology map
Geomorphology		
		• Cross-sections (Merced River and Tenaya Creek)
Caves		
	• Visitation (Crystal, Hurricane Crawl, Soldiers, Lilburn) • Radon (primarily Crystal Cave) • Cave and surface temp-eratures (Crystal, Kaweah, Clough, and Palmer)	
Soils		
	• Pre-and post-burn soil chemistry (Tharp’s) • Chemistry (early versus late-season prescribed fire)	

Atmospheric Monitoring

For detailed and comprehensive information on the atmospheric monitoring program in and around SIEN, please see Appendix C.

Air Quality

In the Sierra Nevada Network, there are three (YOSE, SEQU, KICA) Class I air sheds and one Class II air shed (DEPO). According to the Clean Air Act and subsequent amendments, federal land mangers have an affirmative responsibility to protect visibility, flora, fauna, bodies of water and other resources that may be potentially damaged by air pollution.

Unfortunately, SIEN parks’ air quality is often degraded by pollutants originating from outside park boundaries. Adjacent to Sierra parks is the San Joaquin Valley, recognized as having some of the worst air pollution in the country (Peterson and Arbaugh 1992, Cahill et al. 1996). Pollutants which travel from the San Francisco Bay Area combine with pollutants produced in the San Joaquin Valley. Air flow patterns are such that these pollutants travel into the Sierra Nevada affecting SIEN parks. SEKI has the dubious distinction of having some of the worst air pollution found in any park, nationwide.

Class I parks in the SIEN network have a complex air monitoring program. Supported by the NPS Air Resources Division, these parks are included in several national networks measuring wet and dry deposition, ozone, visibility, mercury, particulate matter, and meteorology. The air resources programs strive to acquire high quality data, make the information available to the public, and taking the opportunity to participate in decisions being made by agencies regulating emissions.

One of the most damaging air pollutants is ozone. Research suggests chronic ozone pollution can lead to shifts in forest structure and composition (Miller 1973). If current ozone concentrations remain relatively constant or increase, they may affect the genetic composition of pine and sequoia seedling populations, and contribute to increased susceptibility to fatal insect attacks and death rates, and decreased recruitment (Miller 1973, Ferrell 1996, Miller 1996). The effects of chronic ozone pollution on other species are not yet known.

Ozone pollution in the Sierra Nevada has produced vegetation damage and is a potentially serious human health issue. YOSE and SEKI have multiple ozone monitors measuring ambient ozone levels. All parks have in, or nearby, passive ozone monitors which are in place during the ozone season (approximately April – October). SEKI uses its stations to produce a daily air advisory for park visitors and employees. Each park facilitates studies designed to better understand ozone effects on vegetation and potential changes to forested landscapes.

Visibility conditions vary by season, generally poor during the summer months and good during winter. Degraded visibility is largely due to organics, sulfates, and nitrates. Smoke from campfires, wildfires, and prescribed burns also cause reduced visibility.

The Sierra Nevada contains thousands of dilute, oligotrophic lakes that are sensitive to changes in climate and atmospheric deposition of acids, nutrients and toxic substances. Recent investigations suggest that lakes throughout the Sierra are undergoing mild eutrophication (Sickman 2003, Goldman 1993). Deteriorating air quality in San Joaquin Valley suggests that human activity may be to blame for these changes. Both YOSE and SEKI monitor acidic inputs and nitrogen deposition in rain and snow events to detect any reduction or increase of these pollutants.

Meteorology

Yosemite, Sequoia & Kings Canyon, and Devils Postpile Meteorology

See Appendix D for summary table of meteorological monitoring. A new metereological station was installed in Devils Postpile in 2005, using SIEN monitoring funds (a lont-term USDA Forest Service RAWS station was removed in 2004).

Wildlife Monitoring (Terrestrial and Aquatic)

Most long-term monitoring of wildlife (terrestrial and aquatic) has been conducted on bears (interactions/incidents with humans), birds, amphibians, a few selected groups taxa with special status (e.g., Sierra Nevada bighorn sheep, California Spotted Owl), etc.

Wildlife inventories are briefly summarized below if considered important as "baseline" for future monitoring efforts. Invertebrates have generally been under-represented in inventory, monitoring, and other studies in Sierra Nevada Network parks.

Multi-species Wildlife Monitoring

Devils Postpile National Monument

Wildlife Observations

Wildlife observation log maintained in visitor center. Entries made by general public and staff. Minimal-to-no quality control. Currently not in electronic format.

Sequoia & Kings Canyon

Wildlife Observations

A database was created to contain "notable" observations of wildlife. Data for each record includes date, species, location, description of observation, name of observer, etc. This database is undergoing considerable redesign by I&M staff, including much QA/QC (circa 2005, 2006).

Yosemite

Annual Wildlife Reports

Annual reports submitted to the Superintendent on wild animal life (much of which concerns mammals) in Yosemite National Park (1929-1979; 50 years) (Yosemite and NPS Archives). For the most part, the information is anecdotal and includes observations by park staff (animals and animal tracks) and experiences of "old timers of the region who have traversed the country." Noted within these reports are staff requests that "more [structured and accurate] studies" be conducted.

Wildlife Observations

A database was created to contain "notable" observations of wildlife (1939 - present; 65 years). Database structure adopted from wildlife observation database at Sequoia and Kings Canyon National Parks. Data for each record includes date, species, location, description of observation, name of observer, etc. All observations–while subjective–do undergo QA/QC (scrutinization) by park wildlife experts (Yose GIS Server: W:\rdbms\Wildlife_Database2000.mdb). This database is undergoing considerable redesign by I&M staff, including additional QA/QC (circa 2005, 2006).

Baseline Inventory: Vertebrates

The "Grinnell Survey", an inventory of the mammals, birds, reptiles, and amphibians was conducted in Yosemite National Park beginning in 1914. It encompassed 1,547 square miles (4000 km^2)(excluding Mariposa Grove and Hetch Hetchy Valley). Elevation of lands surveyed ranged to over 13,000 feet (3,962 m). Field personnel traveled over most regular trails, as well as high points (from where life zones were mapped). This study is not a systematic treatise, but rather contains natural history observations relating to living animals (Grinnell and Storer 1924).

The Grinnell Survey is currently being re-conducted, though employing more systematic methodology (2003 and 2004 field seasons)(Project SIEN-78 *in* \\Inp-yose-ms6\reso\Inventory&Monitoring\ I&MDataDocumentationDatabase.mdb).

Amphibians and Reptiles

Network-wide

Baseline Inventory: Salamanders

A study was conducted to determine salamander status in Sierra Nevada Network Parks (Yosemite National Park, Devil's Postpile National Monument, and Sequoia and Kings Canyon National Parks). Both field and laboratory studies were combined to determine the distributions of species as well (IAR 21298; research permit expiration date 31 December 2003)(Wake and Vredenburg 2002)

Sequoia & Kings Canyon

Baseline Inventory: Terrestrial Salamanders

Collections of terrestrial salamanders were made in Sequoia, Kings Canyon, and Yosemite national parks for the purpose of identification and DNA analysis by the University of California Museum of Vertebrate Zoology as one of the Sierra Nevada Network's biological inventory projects (Wake and Vredenburg 2002). This survey was initiated to provide the distributions of known and newly-identified, described, or detected caudate amphibians (including *Batrachoseps* spp., *Ensatina* spp., *Hydromantes* spp., and *Taricha* spp.). Prior to this study, little or no data were available for terrestrial salamanders in Network parks.

Baseline Inventory: Mountain Yellow-legged Frog

The mountain yellow-legged frog (*Rana muscosa*), once abundant in high elevation waterbodies of the Sierra Nevada, has disappeared from more than 80 percent of its historic range (Bradford and Graber 1994). This decline is largely attributed to predation by introduced trout, although airborne contaminants (pesticides) and pathogens (chytrid fungus) may also be contributing to the decline (Davidson and Shaffer 2002, Sparling and Cowman 2003). In 1997, researchers surveyed 1,059 waterbodies in Kings Canyon National Park to assess the effects of introduced fish on the native mountain yellow-legged frog (Knapp and Matthews 2000). From 2000-2002, researchers surveyed 3,640 waterbodies in the parks to inventory fish and amphibian populations and measure habitat (Knapp 2003). Subsets of these sites were monitored annually from 2002-2004 for the presence of mountain yellow-legged frogs and chytrid fungus.

In 2001, the National Park Service began restoring mountain yellow-legged frog habitat by removing non-native trout from six lakes and the adjacent streams in Kings Canyon National Park. As part of the restoration effort, park staff monitor mountain yellow-legged frog populations before, during, and after trout removals, and measure the abundance of frogs in the restored habitats (Boiano 2004). In 2003, the Sierra Nevada Aquatics Research Laboratory initiated a project to monitor the effects of non-native trout removal on stream invertebrates at restoration sites in Upper Bubbs Creek.

Western Pond Turtle

The National Park Service monitors western pond turtle populations on the North Fork of the Kaweah River and Sycamore Creek to assess the population condition and long-term trends. Starting in 1991, park staff have performed annual surveys using mark-recapture techniques.

Baseline Inventory: Herpetofauna

Reptiles and amphibians have been sampled or recorded as part of other multi-species inventories, such as the Sierra Nevada Network vertebrate inventories that focused primarily on small mammals, reptiles, and amphibians (Moritz et al. 2004, Werner 2004) and within the wildlife observation database described above and below.

Yosemite

Baseline Inventory: Lentic Fauna

The first comprehensive inventory of vertebrate and invertebrate taxa found in Yosemite's lentic habitats (i.e., lakes, ponds, marshes, wet meadows) was conducted from 2000-2002. A total of 3,107 lentic habitats were surveyed for fishes, amphibians, reptiles, fairy shrimp, and habitat conditions; zooplankton and benthic macroinvertebrates were collected at a subset of sites. Surveys indicated the presence of four native amphibian species (Yosemite toad *Bufo canorus*, Pacific treefrog *Hyla regilla*, mountain yellow-legged frog *Rana muscosa*, Sierra newt *Taricha torosa*), one non-native amphibian species (bullfrog *Rana catesbeiana*), four native reptile species (western pond turtle, Sierra garter snake, mountain garter snake, valley garter snake), five nonnative fish species (rainbow trout, California golden trout, Lahontan cutthroat trout, brown trout, brook trout), two fairy shrimp species (spinytail fairy shrimp, mountain fairy shrimp), 19 zooplankton taxa, and 100 benthic macroinvertebrate taxa (Knapp 2003)(*see also: Invertebrates; Fishes below*).

Baseline Inventory: Status of Amphibians

Beginning in 1992, research has been conducted on the status of amphibians within Yosemite National Park. Efforts have been focused on ponds, lakes, meadows, and selected portions of suitable streams as potential breeding sites. A total of 1,659 sites within Yosemite National Park were visited, some more than once. Target species of interest included red-legged frog (*Rana aurora*), cascades frog (*Rana cascadae*), foothill yellow-legged frog (*Rana boylii*), mountain yellow-legged frog (*Rana muscosa*), Pacific treefrog (*Hyla regilla*), western toad (*Bufo boreas*), Yosemite toad (*Bufo canorus*), California newt (*Taricha torosa*), Bullfrog (*Rana catesbeiana*) and a reptile—garter snake (*Thamnophis* spp.)(Fellers 1999).

<u>Baseline Inventory: Special-status Amphibians</u>

Other work was conducted to evaluate the status of Yosemite toads (*Bufo canorus*), Pacific treefrogs (*Hyla regilla*), and mountain yellow-legged frogs (*Rana muscosa*) in Yosemite National Park, and to study the effects of environmental factors on these species–especially climate change. The study included extensive surveys for breeding sites for Yosemite toad *Bufo canorus*, Pacific treefrog *Hyla regilla*, and mountain yellow-legged frog *Rana muscosa*. Measurements of abiotic and biotic parameters in the field were focused mainly on breeding sites of Yosemite toads and, to a lesser extent, Pacific treefrogs (Sadinski et al. 2002).

<u>Baseline Inventory: Special-status Amphibians</u>

In 1997, the U. S. Geological Survey initiated a study to examine the decline of the Yosemite toad (Bufo canorus), Pacific treefrog (Hyla regilla) and mountain yellow-legged frog (Rana muscosa). In addition to water quality parameters discussed in the previous section, the USGS measures the numbers of breeding adults and egg masses per breeding site, hatching success, numbers of metamorphs, and other age classes. Field sites are located at Tioga Pass, Dana Meadows, and Tuolumne Meadows (Fellers 1997).

1.1.1.1 Birds

Network-wide

<u>Baseline Inventories: Birds</u>

In Yosemite, point counts, coupled with detailed habitat descriptions, were the primary methods used to survey birds (1998-2000). A total of 21,072 individual birds were detected at 2,646 point locations across the park using the generalized survey protocol. A total of 149 species were documented, including 15 species not included on a predicted species list. Four guidelines – and five specific projects – are suggested for prioritizing future avian monitoring efforts in the park. (DeSante et al. 2003).

Inventories for Devils Postpile and Sequoia & Kings Canyon are in-progress (2002-2006) and have the following objectives: 1) describe and map the distribution and abundance of birds across habitat type; 2) collect and summarize data on vegetation structure and composition; 3) describe specific habitat associations of bird species; 4) estimate species richness; 5) provide summary information necessary to develop a general monitoring strategy and design that can be implemented by park staff; and 6) provide information that can be used to educate the public. The purpose of this project is to improve baseline data on bird populations and habitat associations of bird species and to develop strategies for long-term monitoring (Siegel and Wilkerson 2004a, 2004b).

Devils Postpile

Monitoring Avian Productivity and Survivorship

In 2002-2004, Point Reyes Bird Observatory (PRBO) implemented a standardized bird monitoring program (10 mist net stations in Soda Springs Meadow using MAPS protocols). PRBO established 15 independent point count stations along the San Joaquin River and Red's Meadow Creek within monument boundaries (Gates and Heath 2003).

Sequoia & Kings Canyon

Monitoring Avian Productivity and Surviorship (MAPS)

MAPS protocol was established by the Institute for Bird Populations (Ralph et al. 1993). The objective is to determine the productivity and survivorship of various species to detect whether population changes on the birds' wintering or breeding grounds. In Kings Canyon, there are currently two MAPS stations, one in Cedar Grove at Zumwalt Meadow, and one in Grant Grove at Lion Meadow. These stations are run in collaboration with The Institute for Bird Populations and Central American biologists, through the Partners in Flight program. The stations were operated from 1991-1993 (Burton et al. 1992, Burton and DeSante 1993) and 2000-2004 (Mazur pers. comm.).

Breeding Bird Surveys

Breeding Bird Surveys (BBS) are conducted at thousands of sites across North America in order to assess regional population trends of migratory species. Two BBS are conducted at Sequoia and Kings Canyon (once each June)—one at Mineral King (SEQU), and one at Cedar Grove (KICA). A total of 50 point counts are conducted based on BBS protocols (2001-present).

Christmas Bird Counts

The Christmas Bird Count is a monitoring program that targets resident birds, and conducted at thousands of sites throughout North America. The count is done for one day, along established routes, with multiple observers, within an established count circle (circa 1960-present).

Peregrine Falcon

Peregrine Falcon (*Falco peregrinus*): The Santa Cruz Predatory Bird Research Group restored peregrine falcons to Sequoia, Kings Canyon, Yosemite, and the surrounding national forests. The Peregrine Falcon was federally de-listed by US Fish and Wildlife Service in 1999 (still listed as endangered in California). There are now at least five active, or potentially active eyries in Sequoia & Kings Canyon. The sites are monitored on an annual basis for occupancy, nesting activity, eggs, young, and successful fledglings. Monitoring also provides data needed for NPS and USFS staff to temporarily close rock-climbing routes that are near eyries.

California Spotted Owl

California Spotted Owl (*Strix occidentalis occidentalis)*: The California Spotted Owl is designated federally endangered (listed by California as a species of special concern). There are four ongoing California spotted owl demography studies within the Sierra Nevada bioregion: (1) Sequoia and Kings Canyon National Parks (1990-present); (2) Lassen National forest(1990-present); (3) Eldorado National Forest (1986-present); and (4) Sierra National Forest (1990 and 1994-present).

Study objectives vary, but generally include all or most of the following: occupancy and density of territory; survival and reproductive success, site fidelity; habitat relations; and diet). Data from the five demographic studies were analyzed in a meta-analysis conducted by Spotted Owl biologists in conjunction with scientists with expertise in population biology, statistics, and data analysis (Franklin et al. 2003). Data from the demographic studies comprise the only empirical information on California spotted owl population trends, survival, and reproduction over the past 7-12 years. See appendix I for more detail on this project.

Important Bird Areas

An Important Bird Area study was conducted in Sequoia & Kings Canyon National Parks and Sequoia and Sierra National Forests in 1999 and 2000 by the Institute for Bird Populations as part of a national effort to classify land areas that are of particular importance to birds (citation). Meadows in both national parks and surrounding national forests were assessed by point counts and mist netting.

Brown-headed Cowbirds

Brown-headed cowbirds are an obligate nest parasite, native to the United States but not the Sierra Nevada. Several species of warblers in particular have fallen precipitously in numbers due to the arrival of cowbirds. A two-year nest study (1995-1996) was done to assess the impact of the cowbirds on native warblers in Cedar Grove area of Kings Canyon National Park (Halterman and Laymon 2000).

Yosemite

Monitoring Avian Productivity and Survivorship (MAPS)

Yosemite has the longest term dataset in our network for monitoring of avian productivity and survivorship. Beginning in 1990, a MAPS station has been run in

Hodgdon Meadow through a partnership with the Institute for Bird Populations. In 1993, four more sites were added: Big Meadow, Crane Flat, Tamarack Meadow, and White Wolf Meadow. All five sites have been run annually since then. All of these sites are meadows, although the mist netting includes forest edge. MAPS sites have been run in the park for 13 years. About 80 species have been captured at these sites, with about 70 of those being species captured in a majority of years (The Institute for Bird Populations 2003).

Christmas Bird Count

The Christmas Bird Count is a monitoring program that targets resident birds, and conducted at thousands of sites throughout North America. The count is done for one day, along established routes, with multiple observers, within an established count circle (circa 1960-present).

Peregrine Falcon

Nest location(s) for Peregrine Falcons (*Falco peregrinus*), primarily within the greater Yosemite Valley surroundings, is determined annually (1978–present; 26 years). Reproductive success data are generally only available for a single nest location that is easily observed. One site within Yosemite Valley is monitored by USFWS, as part of their monitoring program for de-listed species (Thompson, pers. comm.).

Baseline Inventory: Great Grey Owl

The status and distribution of the Great Grey Owl (*Strix nebulosa*) in California is examined based on field surveys conducted in 1979 and 1984, and the analysis of 222 sight and specimen records; the main concentration of this species is in the region of Yosemite National Park. The purpose of this study was to (1) determine the status and distribution of Grey Gray Owls in California, particularly the region of Yosemite National Park, and (2) determine the habitat and nesting requirements, prey preference and abundance, space-use ecology, and behavior of three pairs of Great Gray Owls (1980-1985)(USGS-WERC unpublished data, Winter 1985).

During the winters of 1986-88, and 1989-90, a total of nine Great Grey Owls were monitored in Yosemite National park to determine their winter migration patterns (Skiff 1995).

A sample of the montane meadow systems of Yosemite National Park were surveyed for the presence of Great Grey Owls (1992 and 1994) as part of a long-term population trend study which began in 1992 (Unpublished Natural Resources Report NPS-YOSE-NRW-93-02).

A study was conducted to investigate habitat requirements (based on landscape patterns) of Great Grey Owls in the central Sierra Nevada (Yosemite and adjacent Stanislaus national forest), particularly nest site availability and prey preference and abundance (Greene 1995).

Baseline Inventory: Spotted Owl

Surveys and inventories to determine the distribution and abundance of Spotted Owls (*Strix occidentalis*) were conducted in Yosemite National Park (April through August of 1988 and 1989), covering 577.4 square km of forest habitat at elevations between 1,220 m and 2,465 m (Gould and Norton 1993).

As of the writing of this report (field season 2004), surveys for California Spotted Owls are being conducted to develop a predictive model of their occurrence in Yosemite National Park. The objectives of this project are to: (1) develop models for the relationship between fire, distribution and reproductive success of spotted owls, and certain structural components of their habitat; and (2) examine linkages between fire history and spotted owl abundance with current forest structure and the dynamics of Spotted Owl prey species (Task Agreement Number F8800-03-2400 between Yosemite and USGS).

1.1.1.2 Mammals

Multi-Park

See Multiple Vertebrate Groups Studies section below and Fire-related Monitoring sections for more information on small mammals monitoring.

Sequoia & Kings Canyon

Focal Resource: Black Bear

Monitoring of human/bear incidents and other bear activities (see also, description under Yosemite, above): The Bear Information Management System (BIMS) is used to record bear incidents and observations in SIEN parks. The purpose of BIMS is to track temporal and spatial trends of bear activities, to track activity of specific bears, and to track effectiveness of outreach and educational efforts and actions taken by management in response to incidents. This system has been in place for more than 20 years, but is highly subject to observer bias and has been used inconsistently.

Bear research: Bear population and behavioral studies were conducted in Yosemite and in Sequoia and Kings Canyon beginning in the 1970s until presently, and more is planned in Sequoia. Some of this work provided robust estimates of population size and structure in local areas (e.g. Yosemite Valley, Giant Forest), but these are not amenable to extrapolation to larger landscapes, and were not conducted for sufficient duration to detect change.

Focal Resource: California Ground Squirrel

California ground squirrels (*Spermophilus beecheyi*) were inventoried in campgrounds in Sequoia National Park (1984-1998) to monitor the relative abundance due to concerns that the number of squirrels in the campgrounds was too high and needed to be controlled.

Focal Resource: Yellow-bellied Marmots

Yellow-bellied marmots (*Marmota flaviventris*) were studied in the Mineral King area of Sequoia National Park from 1987 to 1993 to try to determine why marmots were chewing on car parts (and often causing damage) during early to mid summer of each year. Data were collected on blood chemistry, movements and population structure of the marmots. Please see sections 1.5.1.4.4 and 1.5.1.4.7 for additional information about monitoring of small mammals associated with fire effects studies and the Multiple Vertebrate Group Studies section below for baseline inventories of small mammals.

Focal Resource: Bats

Exit Counts—The Sequoia and Kings Canyon Cave Specialist and staff conduct exit counts for bats at Clough Cave in Sequoia National Park (1996 to present).

Baseline Data—Koshear and Lawton (1993) did a 10-day survey through the Kaweah, Kern and Kings River drainages in Sequoia National Park to study bats. Mist nets were used to sample bats during their active period and their sounds were recorded to aid in species identification. The objective of this study was to develop a baseline database regarding bat species composition, abundance, distribution and ecology.

Structure Use—Pierson and Heady (1996) conducted a survey to determine the bat use of buildings in Giant Forest, prior to building removal as part of a restoration project in Sequoia National Park. Recommendations included additional monitoring and some mitigation to protect bat habitat in the area.

Sierra Nevada Network Bat Inventory Project—The purpose of this project was to document at least 90% of bat species expected to occur in Devils Postpile National Monument and Sequoia and Kings Canyon National Parks. Literature and museum searches and extensive field sampling (mist-netting and acoustic survey) was conducted. Sampling was initiated in Devils Postpile in August 2001, and 10 bat species were newly documented for the monument (Pierson and Rainey 2002). Sequoia and Kings Canyon field sampling began during the summer of 2002. Of the 17 species expected to occur, 15 of these were identified in Kings Canyon; 14 in Sequoia. Three species were newly documented for both parks (Pierson and Rainey 2003).

Other products for Sequoia and Kings Canyon and Devils Postpile from Pierson and Rainey's work for SIEN will include: (a) summaries of information on Sierra Nevada bat species from literature reviews; and a literature review that includes identification of species sensitive to disturbance; and (b) identification of bat species detected or mist-netted, characterization of breeding status, discussion of locations/habitats where species were detected and foraging areas/roosting features in those habitats. Two additional years of field work (through 2005) will be conducted

Forest Carnivores

Four species of Sierra Nevada carnivores are special status species: California wolverine (*Gulo gulo*), Pacific fisher (*Martes pennanti pacifica*), American marten (*Martes pennanti pacifica*), and Sierra Nevada red fox (*Vulpes vulpes necator*). The American (pine) marten and Pacific fisher are declining throughout their range. California wolverines are elusive and there has been no definitive documentation of their occurrence in California in over twenty years.

Two recent inventories in Sierra Nevada parks have provided additional information about some of these species and other carnivores: (1) assess the presence and distribution of American marten, Pacific fisher and California wolverine and measure their associated habitats (2002-2004). Non-target species surveyed include: spotted skunk (*Spilogale putorius*), gray fox (*Urocyon cinereoargenteus*), ringtail (*Bassariscus astutus*), weasel species (*Mustela* spp.), coyote (*Canis latrans*), mountain lion (*Puma concolor*), black bear and Virginia opossum (*Didelphis virginiana*).

Sierra Nevada Bighorn Sheep

See project description, below, under Yosemite.

Yosemite

Focal Resource: Rare Mammals

A study is being conducted (1992 – present) to determine the status and distribution of Pacific fisher (*Martes pennanti pacifica*), Sierra Nevada red fox (*Vulpes vulpes necator*), and California wolverine (Gulo gulo luteus) in Yosemite National Park; species designated as Category II (being considered for protection under the Endangered Species Act) (Federal Register, 21 November 1991, 56:58804-58836). A species is designated Category II when the USFWS receives a petition for listing but lacks the information necessary to determine whether Endangered Species status is warranted.

Focal Resource: Black Bear

Monitoring of human/bear incidents and other bear activities: Monitoring of black bears (*Ursus americanus*) is limited to individual bears, not the population. The Bear Information Management System (BIMS) is used to record bear incidents and observations in SIEN parks. The purpose of BIMS is to track temporal and spatial trends of bear activities, to track activity of specific bears, and to track effectiveness of outreach and educational efforts and actions taken by management in response to incidents. This system has been in place for more than 20 years, but is highly subject to observer bias and has been used inconsistently. The ultimate goal is to develop management strategies to mitigate conflicts. (Thompson and McCurdy 1995, Yosemite Bear Council 2002).

At Yosemite, data collected annually (1960 – present; 44 years) are related to human-black bear interactions (injuries and property damage). Some behavioral data is collected for individual animals where possible (range, reproductive success)(Thompson, S., personal communication).

Bear research: Bear population and behavioral studies were conducted in Yosemite and in Sequoia and Kings Canyon beginning in the 1970s until presently, and more is planned in Sequoia. Some of this work provided robust estimates of population size and structure in local areas (e.g. Yosemite Valley, Giant Forest), but these are not amenable to extrapolation to larger landscapes, and were not conducted for sufficient duration to detect change.

Focal Resource: Sierra Nevada Bighorn Sheep

Sierra Nevada bighorn sheep (*Ovis canadensis sierrae*) are federally and state listed as Endangered. The entire subspecies was first censused during the 1970s (Wehausen 1980) when it consisted of only two surviving populations which spent winters on the eastern slopes of the Sierra in the Inyo National Forest, and their summers near the crest. The larger of the two populations spent a portion of the year in Kings Canyon National Park; the second herd occasionally wandered into Sequoia National Park from the Inyo N.F. During the period 1979-1988, bighorn sheep were translocated from the larger herd to sites in the Inyo National Forest where sheep had once been reported, to establish three additional herds in the Sierra Nevada. One of these introduced herds includes a portion of Sequoia Natonal Park within its range, and a second sporadically visits Yosemite National Park. In 2002 a band of sheep was discovered near Bubbs Creek which appears to spend the entire year west of the Sierra crest in Kings Canyon National Park; it likely established recently from the nearest established herd.

Monitoring of Sierra bighorn herds

The California Department of Fish and Game (CDFG) has been the agency with principal responsibility for monitoring Sierra Nevada bighorn sheep. Attempts have been made to census all extant herds annually since the early 1980s, using various combinations of agency personnel from CDFG, the National Park Service, the U.S. Forest Service, and the Bureau of Land Management, as well as volunteers. These efforts have been coordinated by Dr. John D. Wehausen, generally under contract to CDFG. Population models have then been employed to convert fragmentary raw census data into estimates of population size and structure.

Estimated population size for the entire subspecies has varied from 310 in 1986 to 100 in 1998. The principal controlling factor appears to be mountain lion predation. The species is soon to be recognized as a new, distinct subspecies, *Ovis canadensis sierrae*.

Focal Resource: Bats

Eight species of bats in the Sierra Nevada are federal and/or state species of concern: Pallid bat (*Antrozous pallidus*), Townsend's/pale big-eared bat (*Corynorhinus townsendii*), spotted bat (*Euderma maculatum*), greater western mastiff bat (*Eumops perotis Californicus*), long-eared myotis (*Myotis evotis*), fringed myotis (*Myotis thysanodes*), long-legged myotis (*Myotis volans*) and Yuma myotis (*Myotis yumanensis*)

Bat surveys have been ongoing in Yosemite since 1993 (10 years). Three survey methods are used: bridge roost, acoustic, and mist-netting. Results include species diversity, seasonal and elevational distribution, relative abundance, and reproductive status (Pierson et al. 2001).

Another bat project (FY 2002) was initiated to investigate the seasonal and elevational distribution of bats in Yosemite in response to aquatic insect abundance and distribution (sites were sampled at monthly intervals from May through October). Stable nitrogen isotopes will be examined to determine the role that aquatic ecosystems play in the structure and function of terrestrial communities (*Citation ?*). Investigators will resample insects and bats at the 2002 sample sites (Pierson and Rainey- SIEN unpublished data).

In 2003, newly designed bat detectors were installed at several locations in Yosemite to monitor bats on a year-round basis (SIEN AAWRP 2003).

Focal Resource: Mountain Lion

In 1994, a dramatic rise in the number of reported mountain lion (*Puma concolor*) sightings and apparent changes in mountain lion behavior raised concerns about the potential for conflict between lions and humans in developed areas in Yosemite National Park. To assess the level of threat these individuals posed to human safety, a study was conducted to determine why mountain lions had increased their use of Yosemite Valley and other developed areas in the park. Seven mountain lions were captured and equipped with radio-telemetry collars; nine additional lions occurred in the study area that were never captured (USGS-WERC unpublished data).

Focal Resource: Mule Deer

Yosemite-region mule deer (*Odocoileus hemionus*) herds are monitored annually (population size and health) in Yosemite and surrounding national forests (Stanislaus and Sierra or Tuolumne)(*Citation*). Composition counts are obtained (i.e., number of bucks, does, and fawns). In addition, hunting statistics are used as an indicator for estimating mule deer numbers (e.g. car counts—carcasses on tops of cars or in bed of trucks). Other data gleaned from examining such carcasses (e.g. antler growth) includes indication of overall deer health.

1.1.1.3 Fishes

Devils Postpile

The California Department of Fish and Game conduct annual fish population assessments on the Middle Fork of the San Joaquin River. Monitoring began sometime around 1997; some monitoring continues (funding dependent).

Sequoia & Kings Canyon

Sequoia and Kings Canyon staff monitors fish density, species composition and habitat variables at twelve sites to evaluate the effects of human access, elevation and fishing regulations on fish populations. Monitoring was initiated in 1980 and is repeated approximately every five years.

<u>Focal Resource: Little Kern golden trout</u>

Found in headwater streams of Sequoia National Park, are listed as threatened under the federal Endangered Species Act. The National Park Service and California Department of Fish and Game monitor fish populations and pool habitat on Soda Springs Creek to assess annual and long-term changes in restored and source populations of Little Kern golden trout.

Yosemite

<u>Baseline Survey: Fishes</u>

A single-season survey of the status of fish populations in 102 “planted” lakes. This report: (1) summarizes the findings for each lake, including stocking history; and (2) a broader discussion and qualitative description of each lake, including shoreline and nearby terrain, inlet/outlet stream(s), bottom sediment, aquatic plant(s), and food availability for fishes (invertebrate type and abundance). In addition, the report notes that “[m]ost of these lakes were [previously] surveyed close to or in 1953” (Botti 1977). *Editor’s note: using a cursory look at the report, amphibian larvae are not listed as present as a food source, but the researchers do not note whether they were included in the target survey.*

<u>Baseline Inventory: Lentic Habitat</u>

The first comprehensive inventory of vertebrate and invertebrate taxa found in Yosemite's lentic habitats (i.e., lakes, ponds, marshes, wet meadows) was conducted from 2000-2002. A total of 3,107 lentic habitats were surveyed for fishes, amphibians, reptiles, fairy shrimp, and habitat conditions; zooplankton and benthic macroinvertebrates were collected at a subset of sites. Surveys indicated the presence of four native amphibian species (Yosemite toad, Pacific treefrog, mountain yellow-legged frog, Sierra newt), one non-native amphibian species (bullfrog), four native reptile species (western pond turtle, Sierra garter snake, mountain garter snake, valley garter snake), five nonnative fish species (rainbow trout, California golden trout, Lahontan cutthroat trout, brown trout, brook trout), two fairy shrimp species (spinytail fairy shrimp, mountain fairy shrimp), 19 zooplankton taxa, and 100 benthic macroinvertebrate taxa. (Knapp 2003)(*see also: Invertebrates, below; Amphibians and Reptiles, above*).

1.1.1.4 Invertebrates

Devils Postpile

Benthic Macroinvertebrates

The National Park Service and California Department of Fish and Game sampled benthic macroinvertebrate communities using the California Stream Bioassessment Procedure, a biological monitoring tool used to detect change in aquatic systems (Schroeter and Harrington 1995). They sampled in 1994 and 1999, concurrently with the water quality monitoring discussed in the previous section.

Meadow invertebrates

Stream and terrestrial invertebrate sampling the San Joaquin River and adjacent meadows of Devils Postpile National Monument is being conducted across two seasons (2003-2004)(Agreement with Jeff Holmquist - UC Sierra Nevada Aquatic Research Lab and White Mountain Research Station). The objectives of this project are to: 1) describe the spatial and temporal distribution of invertebrates; 2) document the presence of sensitive taxa; 3) establish a baseline against which impacts can be assessed; and 4) identify the invertebrate groups most likely to prove informative as monitoring elements. The final product will be provide a framework for protection and monitoring of invertebrates.

Sequoia & Kings Canyon

Giant Sequoia Forest Invertebrates

Staff from the UC Davis Bohart Museum collected insect data from giant sequoia forest areas and adjacent vegetation types in the Kaweah River drainage of Sequoia National Park (2001-2002) to provide additional baseline information on park insects in and around sequoia forests as well as develop baseline information on Chironomids as water quality indicators. Data were collected primarily by drift net (primarily for Chironomids), malaise traps, and sweep nets (Kimsey and Cranston 2002). The purpose of this dataset was (SIEN biological inventory project-NPS 2001).

Yosemite

Baseline Inventory: Lotic Benthic Invertebrates

Lotic benthic invertebrates were collected from riffles, glides (runs), pools, wood, and margin habitats from eight sites on the Merced River in Yosemite Valley, Yosemite National Park. Collections were made near the beginning of October during four contiguous years, 1992-1995. A total of 338 taxa were collected over the four years. In general, total taxon richness was similar in 1992, 1993, and 1995. Total taxon richness was somewhat higher in 1994. Riffle and margin habitats had near equal mean taxon richness and were higher than glide, pool, or wood habitats (Carter 1997).

Baseline Inventory: Lentic Macroinvertebrates

This is the first comprehensive inventory of vertebrate and invertebrate taxa found in Yosemite's lentic habitats (i.e., lakes, ponds, marshes, wet meadows). A total of 3,107 lentic habitats were surveyed for fishes, amphibians, reptiles, fairy shrimp, and habitat conditions; zooplankton and benthic macroinvertebrates were collected at a subset of sites. Surveys indicated the presence of four native amphibian species (Yosemite toad, Pacific treefrog, mountain yellow-legged frog, Sierra newt), one non-native amphibian species (bullfrog), four native reptile species (western pond turtle, Sierra garter snake, mountain garter snake, valley garter snake), five nonnative fish species (rainbow trout, California golden trout, Lahontan cutthroat trout, brown trout, brook trout), two fairy shrimp species (spinytail fairy shrimp, mountain fairy shrimp), 19 zooplankton taxa, and 100 benthic macroinvertebrate taxa (Knapp 2003)(*see also: Fishes, Amphibians and Reptiles, above*).

<u>Pilot Monitoring: Meadow Invertebrates</u>

A cooperative agreement was initiated with Jeff Holmquist (identified above) to conduct a pilot study to assess the efficacy of invertebrates as indicators of meadow change. A literature review to inform the network's conceptual modeling was completed in 2003, and the pilot study field work was initiated in 2004 in Tuolumne Meadows of Yosemite National Park. The objectives are to: 1) produce an initial inventory of invertebrates within diverse habitats of one Sierra Nevada Network meadow; 2) quantitatively document the spatial and temporal distribution of invertebrates within the meadow; 3) document the presence of sensitive invertebrate taxa (listed species and species of concern); 4) provide a first approximation of a baseline against which the impacts of management and recreational activities on meadow systems can be assessed; and 5) identify those groups, species and/or other elements most likely to prove informative as indicators for long-term monitoring.

<u>Focal Resource: River Macroinvertebrates</u>

The Yosemite Institute, in conjunction with the Sierra Nevada Aquatics Research Laboratory, conduct an aquatic biomonitoring program along a short section of the Merced River. This is an environmental education program where students collect stream invertebrates and divide them into categories that reflect "tolerances for polluted water" to evaluate stream health. Sampling is conducted annually (P. Devine, pers. comm.)

Terrestrial Vegetation

Sequoia, Kings Canyon and Yosemite National Parks have a rich history of vegetation-related inventories, research and monitoring projects. Most of the long-term vegetation monitoring in these parks has been related to measuring the effects of management programs (especially fire, exotic plant control and restoration), recreation (especially pack stock grazing) and air pollution. Aside from fire effects plots established in 1992, Devils Postpile has not had the staffing or resources to do long-term vegetation monitoring.

All parks have had vegetation inventories done that are of value as baseline data for long-term monitoring. These include vegetation maps (Yosemite, in progress), vascular plant surveys in the 1990s in Sequoia, Kings Canyon and Yosemite (P. Moore and S. Haultain, pers. comm.), citation for Yosemite NRI—Moore, van Wagtendonk?), a vascular plant inventory in Devils Postpile (Arnett and Haultain 2003), and rare plant surveys for all parks (in-progress).

1.1.1.5 Plant Populations or Communities

Meadows, Wetlands and Riparian Areas

Sierra Nevada montane and non-meadow riparian areas are recognized as Globally Important Bird Areas (American Bird Conservancy, National Audubon Society) and as Priority Habitats for bird conservation in the Sierra Nevada Bioregion (Siegel and DeSante 1999). Participants in Sierra Nevada Network vital signs workshops identified meadows as a priority for long-term monitoring due to their ecological importance, their potential sensitivity to climatic change and their use as recreational and pack stock grazing sites by backcountry travelers.

Devils Postpile National Monument

While there is not currently a comprehensive monitoring program in place for meadows in the monument, a meadow restoration project is underway in Soda Springs Meadow and some baseline inventory data are being collected on aquatic and terrestrial invertebrates to determine if there will be changes in invertebrate communities in response to reduction in social trailing and restoration of more natural water flow patterns in the meadow (Holmquist, in progress). Other monitoring associated with Soda Springs Meadow is a songbird demographic monitoring project (Gates and Heath 2003), discussed in more detail under Terrestrial Animals section. Vegetation monitoring plots established (confirm with Athena and Deanna).

Sequoia and Kings Canyon National Parks

Most of the meadow monitoring in Sequoia and Kings Canyon National Parks has focused on measuring effects of grazing by pack stock on wilderness meadows (S. Haultain, pers. comm.). The Plant Ecologist in Division of Natural Resources, with support from backcountry patrol rangers, monitors:

- The annual distribution and abundance of overnight pack stock use in Sequoia and Kings Canyon National Parks.
- Species composition in five pairs of meadows—each pair consisting of one grazed meadow and one ungrazed reference meadow.
- Residual biomass, or the amount of above ground plant material remaining in a meadow at the end of the growing season. This provides park managers with information on the status of selected wilderness meadows that are being grazed. In the long term, these data will enable park managers to set appropriate use

levels for popular meadows by establishing site specific minimal residual biomass standards. In the short term, residual biomass serves as an indicator of meadow conditions that can be referred to when timely decisions are needed to prevent or mitigate the effects of overgrazing.

- Coarse trends in meadow condition and species composition (e.g. invasion by woody species) through use of repeat photography. Collection currently consists of repeat photographs of approximately 250 scenes throughout meadows in Sequoia and Kings Canyon National Parks, which are retaken as time and resources allow. Collections of photos specific to each backcountry patrol area are compiled into photo binders that are sent out to each station in the spring of each year.

These complementary datasets are combined to illuminate the relationship between pack stock use and meadow condition, and to inform management decisions regarding pack stock use and grazing within the two national parks.

Yosemite National Park

<u>Monitoring associated with vegetation restoration:</u> In Yosemite, Science and Resources Management staff members have undertaken numerous wetlands and meadow restoration projects. Some of these projects have multi-year monitoring projects associated with them.

- Pavillion Square, Sentinel Meadow Restoration: In spring 1993 this formerly developed area was restored through removal of fill and re-contouring. Five transects were established to monitor: 1) vegetation change following site treatment, 2) proportion of native and nonnative plant species, and 3) assess relationships between establishment of nonnative plant species and water table. Untreated control transects were established for comparison to treated areas.

- Cooks Meadow Restoration: 7 year project (1998 - present). Monitoring is being conducted to document changes in hydrology and vegetation following restoration of a lower montane wet meadow in Yosemite Valley. Restoration involved removal of fill, filling ditches, installation of culverts under roads, installation of boardwalks in place of paved trails, and removal of nonnative plants. Monitoring (*need to look at monitoring plan to summarize parameters being monitore database)*

- Happy Isles Fen Restoration: 8 year project (2001-2009). Monitoring is being conducted to document changes in species composition. The Happy Isles fen is a four acre wetland representative of a rare plant community. Site restoration involved removal of fill, re-contouring, and revegetation. Monitoring (*need to look at monitoring plan to summarize parameters being monitored- or have you already done this in the database)*

- Eagle Creek Restoration: 2 year project (2002-2004). The site restoration intended to retard erosion and encourage re-establishment of native stream bank vegetation at the confluence of Eagle Creek and the Merced River in Yosemite Valley.

- Packstock: Get information about monitoring of stock use effects in meadows from Laurel Boyers and Mark Finch

- Packstock: The Yosemite Research Office conducted a study on the effects of stock use on meadows (J. van Wagtendon, P. Moore, and M. McClaran).

1.1.1.6 Forest Demography

Sequoia and Yosemite National Parks

Permanent forest reference plots were established in Sequoia and Yosemite National Parks to develop a quantitative description of Sierra Nevada forest dynamics across an elevational and latitudinal gradient. From 1982 to 1995 three separate programs orchestrated the establishment of permanent forest plots in Sequoia and/or Yosemite: Sierran Pulse (Dr. Jerry Franklin, University of Washington), Watershed Program (Dr. David Parsons, formerly of Sequoia NP Research Office—Parsons et al. 1992), and USGS Global Change Research Program (Stephenson and Parsons 1993, Stephenson et al. 2004). Forest demography is now monitored in all plots under the USGS Global Change Research Program.

There are nineteen plots in Sequoia and five in Yosemite. They range from about 1,500 m to 3,300 m in elevation; plot size ranges from 0.9 to 2.5 hectares. Forest types represented include: ponderosa pine-mixed conifer, white fir-mixed conifer, xeric conifer, red fir, and subalpine. All trees above 1.37 m in height are tagged and monitored annually for mortality, disease, and insect and weather damage. When trees die, factors associated with death are identified and recorded. New establishment is monitored by tagging trees annually that reach 1.37 m in height. Every five years diameters of trees are re-measured to monitor tree growth. Two of these plots were burned in 1990; mortality rates and factors associated with death of trees have been compared between burned and unburned stands. Forest seedling dynamics and forest seed rain research and monitoring projects were initiated in these plots in 1999 and 2000, respectively. Long-term demographic data associated with these plots have yielded a variety of publications (Parsons et al. 1992; Mutch and Parsons 1998; van Mantgem et al. in press, van Mantgem et al. 2003), and contributed to additional research with academic scientists (e.g. Kern 1996; Miller and Urban 1996, 1999). See Appendix I for more information on the Sierra Nevada Global Change Research Program.

To aid in development of forest restoration targets, Yosemite is undertaking follow-up data collection on 61 forest plots that first were inventoried in 1911. Plots are in ponderosa pine and mixed conifer forests. Transects used for data collection are large (4 acres each), systematically located, spread over a large area, and were sampled before the major impacts of fire suppression had become apparent.

Stand and landscape-scale structure and composition of these forests will be summarized, thereby providing concrete targets for use in planned forest restoration activities (as specified in the Yosemite Fire Management Plan). This step will quantify the demographic structure of these transects, their spatial patterns, and their relationship to environmental and topographic variables. It will be statistically oriented and dependent on Geographic Information System (GIS) analysis. Second, the original transects will be re-sampled to quantify changes that have occurred in the past 90+ years, when forests were subject to substantial human impact. Analysis of results of re-sampling will be based on stratification of transects according to their original structural characteristics, topographic and elevation positions, and severity of fire damage from the 1996 Ackerson fire (which burned part of the study area). Forest change will be quantified with respect to these explanatory variables.

Yosemite resource staff are seeking funds to conduct the same work on adjacent Stanislaus National Forest. Combined data, covering a 150 mi^2 area, will allow comparison of temporal changes between these two land management agencies, which have had very different histories of vegetation management.

Contact: Dr. Jim Bouldin, PhD, Research Ecologist, USDA Forest Service Pacific Southwest Research Station, Davis, CA

1.1.1.7 Alien Invasive Plants

In Spring 2005, SIEN I&M staff hosted a network-wide alien invasive plant workshop, attended by park resources management staff, as well as regional, WASO, and other national invasive plant experts across the country. The purpose of this workshop was to identify and refine network invasive plant objectives and priorities, with special emphasis on early-detection monitoring. The results of this workshop are available (Moritsch et al. 2005, in progress).

Devils Postpile

The most problematic alien invasive plant in the monument is bull thistle (*Cirsium vulgare*). Monument staff began eradicating bull thistle, as time was available, after the 2001 vascular plant inventory identified it as the most invasive of the eight alien invasives identified in the monument (Arnett and Haultain 2003). The California Exotic Plant Management Team has visited the monument to remove bull thistle and other alien invasives.

Sequoia, Kings Canyon and Yosemite

The purpose of nonnative plant inventory and monitoring in these parks is to (1) document location and abundance of exotic plant infestations, (2) document management actions, (3) document exotic plant taxa and their priorities for management, (4) summarize yearly accomplishments, and (5) monitor effectiveness of control actions over time. Areas to be searched on a regular basis are documented, including roadsides, campgrounds, housing areas, developments, trailsides, dumps, corrals and pack stations, pastures, burned areas, and park boundaries throughout the parks. Methods include mapping (with GPS) infestations of nonnative plants as points or polygons. Associated data includes ocular cover estimates, number and density of plants, elevation, aspect, overstory cover, plant community, land use, and control method.

A nonnative plant inventory done by USGS in the late 1990s for Sequoia, Kings Canyon and Yosemite targeted developed areas and trails and provided a threat assessment and management prioritization for nonnative plants in these parks (Gerlach et al. 2001). Additional alien invasive plant surveys are currently underway (fieldwork 2005) for riparian areas in Yosemite and a recently burned area in Sequoia National Park, through the network's Inventory & Monitoring program.

Yosemite

Invasive Plant Management Plan / EIS

Yosemite is currently (circa 2005, 2006) preparing a Invasive Plan Management Plan/EIS which in part may inform future early detection or trends monitoring.

Alien Invasive Surveys

Yosemite National Park conducted alien invasive plant surveys in 1998 and 1999, primarily focused on anthropogenically disturbed areas, including campgrounds, picnic areas, developments, corrals, roads, and trails. Survey results indicated 130 nonnative species occurred in these anthropogenically disturbed sites. The majority occurred at lower elevations, but nonnatives were recorded at some of the highest elevations surveyed. At that time, there was little information on the presence of nonnative plants in areas of natural disturbance (riparian areas) in Yosemite.

Alien Invasive Survey: Riparian Habitat

In 2005, SIEN funded a plot-based survey of alien invasive plants within the Merced River watershed. The purpose of this project was to refine knowledge of vegetation conditions—specifically non-native plant species presence—in areas subject to natural disturbance, specifically riparian habitat. Results will provide a baseline against which changes in distribution and abundance of selected species can be measured, and will assist with prioritization of individual sites and species suitable for monitoring. The project focused on riparian habitat within the entire Merced River drainage. The results of this project are in progress (PRBO in prep).

1.1.1.8 Plant Phenology

Sequoia National Park

From 1988 to 1990, the Research Office in Sequoia and Kings Canyon National Parks monitored seasonal timing of growth of giant sequoias (*Sequoiadendron giganteum*) using band dendrometers and increment corers (Mutch 1990). From 2000 through 2004, Sequoia and Kings Canyon National Parks' Fire Ecologist has monitored growth of 3-12 trees (*Pinus ponderosa, Pinus lambertiana, Abies concolor, Calocedrus decurrens, and Quercus kelloggii*) in the Giant Forest area. The purpose of these projects is to determine timing of onset of earlywood and latewood growth and cessation of growth for Sierra Nevada tree species. This information is needed to better estimate the seasonal timing of fire scars in the tree-ring record (Swetnam et al. 1991, Caprio and Swetnam 1995). Data, if collected on a long-term basis in conjunction with meteorological data, could also be of interest in examining effects of climate change on tree phenology.

1.1.1.9 Air Pollution Effects on Vegetation

Numerous inventory and research studies, and a few long-term monitoring projects, have documented ozone effects on yellow pines (*Pinus ponderosa and P. jeffreyi*) and a few other species, e.g. black oak (*Quercus kelloggi*) and giant sequoia (*Sequoiadendron giganteum*). It is primarily the pine studies that collected long-term data, and these are summarized below by topic or project, rather than by park:

<u>Baseline ozone effects survey</u>, Sequoia and Kings Canyon: Fifty-four, 10-tree permanent plots were established in Sequoia and Kings Canyon National Parks between 1980 and 1982 to determine the distribution and intensity of ozone injury to two indicator species (ponderosa pine *Pinus ponderosa and* jeffrey pine *Pinus jeffreyi*) and provide baseline data. Plot ratings ranged from "no symptoms" to "severe symptoms." Moderate-to-severe damage appeared to occur in open drainages and on aspects that directly face San Joaquin Valley (Warner et al. 1983, Duriscoe and Stolte 1989).

<u>The Sierra Forest Ozone Response Study (Project FOREST)</u>: This joint NPS/USFS effort, begun in 1989, established a network of plots throughout the Sierra Nevada and San Bernardino Mountains to evaluate effects of ozone on *Pinus ponderosa* and *Pinus jeffreyi*. The network includes six plots at Sequoia and Kings Canyon National Parks and six plots in Yosemite National Park, along with a total of 50 additional plots in Tahoe, Eldorado, Stanislaus, Sierra and Sequoia National Forests. These plots were re-visited in 1993, 1996 and 2001 and evaluated for foliar injury (chlorotic mottling), needle retention, and other variables. Dendroecological studies also evaluated effects of ozone on radial growth of trees in these stands (Peterson et al. 1989, Peterson et al. 1991).

An additional plot, not part of the original study network, was established at Devils Postpile in 1993 and re-read in 1996 and 2001. This single 50-tree plot, encompassing about 2 ha, was established to monitor effects of ozone air pollution on Jeffrey pine. Jeffrey pine was found to be rare in Devils Postpile after significant mortality caused by the 1992 Rainbow wildfire.

<u>Forest Inventory and Analysis (FIA) plots</u>: One plot was established in Sequoia National Park specifically to examine ozone effects on multiple species. Two plots were established outside the boundary of Yosemite National Park for the same purpose. These plots are read annually by USFS staff.

Physioecological studies: Beyers et al. (1992) evaluated the effects of long-term ozone exposure and drought on photosynthetic capacity of ponderosa pine during summer and fall, 1988-1990. Patterson and Rundel (1989) examined physiological responses (photosynthetic rates and stomatal conductance) between seasons and among ozone-sensitive and ozone-resistant Jeffrey pine for two years, 1987-1988.

1.1.1.10 White Pine Blister Rust Effects on Five-Needle Pines

An extensive ground survey of white pine species in Sequoia and Kings Canyon National Parks was conducted from 1995-1999 (Duriscoe and Duriscoe 2002). The objectives of the project were to: 1) Assess geographic extent and severity of white pine blister rust on the following species: *Pinus lambertiana, Pinus monticola, Pinus albicaulis, Pinus balfouriana, Pinus flexilus*; 2) delineate the geographic distribution of the above pine species based on a synthesis of all currently available information; and 3) establish permanent monitoring plots to provide a baseline for long-term monitoring of rust incidence and severity–151 permanent plots were established.

1.1.1.11 Vegetation Change – Repeat Photography Project

The USGS Sequoia and Kings Canyon Field Station (Bueno et al. in prep.) used repeat photography to document vegetation changes in ponderosa pine forests and oak-chaparral communities of Kings Canyon in Kings Canyon National Park, and compared these changes with those documented in Yosemite Valley. Yosemite Valley and Kings Canyon share similar geologic and human histories, and a comparison of vegetation change in the two areas could provide new information for management. Unlike other repeat photography projects, they quantitatively analyzed some photo pairs (as well as qualitatively described all pairs) using a simple, dot-grid overlay counting method. They concluded that, although there are apparent density and cover increases in plant communities of Kings Canyon, they are not as dramatic as those documented for Yosemite Valley. Changes in vegetation conditions in Kings Canyon followed a change in fire regime of the area after Euroamerican settlement. In contrast, changes observed in Yosemite Valley may be a result of a change in fire regime as well as human induced changes in hydrology.

Fire-related Monitoring

The purpose of fire monitoring programs in Sierra Nevada parks is to provide effective evaluation of the parks' fire management programs. Fire monitoring programs are designed to determine whether fire and resource management objectives are met, as well as to document any unexpected consequences of fire management activities (NPS 2003).

The parks' fire monitoring programs began in 1982 (or earlier with Kilgore work?) for Sequoia & Kings Canyon, 1978 for Yosemite, and 1992 for Devils Postpile. The programs in both Sequoia & Kings Canyon and Yosemite initially focused on monitoring weather and fire behavior, vegetation, and dead-and-down surface fuels in giant sequoia groves and other early experimental prescribed burns in mixed-conifer forests. As prescribed-fire programs evolved, the monitoring programs expanded to other vegetation communities. Some fire monitoring in Sierra Nevada parks is guided by the Fire Monitoring Handbook (FMH; National Park Service 2001) which establishes goals, objectives, and protocols for fire-related monitoring Servicewide—this program became a Servicewide standard in 1988. In recent years, Sierra Nevada fire-monitoring programs have broadened to include additional vegetation, wildlife, water, and/or fire regime components. Devils Postpile does not currently have a completed Fire and Fuels Management Plan (NPS *in progress*); however, fire effects monitoring plots were established in association with a 1992 wildfire that burned approximately two-thirds of the monument.

More information on fire can be found in SEKI and YOSE Fire and Fuel Management Plans (NSP 2003, 2004).

Environmental and Fire Conditions

Monitoring of environmental and fire conditions are the first two levels of monitoring described in the Fire Monitoring Handbook (National Park Service 2001). NPS resources management and/or fire management staff collect information on environmental conditions (weather [current and forecasted], fuel model) and fire conditions (name, location, slope, aspect, spread, intensity, smoke transport, and dispersal) for all wildland and prescribed fires. Monitoring these environmental and fire conditions provides information to guide fire-management strategies for both wildland and prescribed fires.

Recently, Sequoia & Kings Canyon and Yosemite National Parks have been implementing monitoring of burn severity (2002–present). Using Composite Burn Index rankings and Landsat images, fire monitoring crews are ground-truthing data from large wildland fires to assess accuracy of satellite-imagery interpretation of burn severity.

USGS-BRD staff in Sequoia and Kings Canyon have monitored weather, fuel moisture and fire behavior in association with a national Fire/Fire Surrogate project (USGS 2004). See section on USGS fire-related studies below and Appendix I.

Fire Effects on Vegetation and Fuels

Monitoring levels 3 and 4 of the Fire Monitoring Handbook (National Park Service 2001), describe short- and long-term monitoring of the effects of fire on fuels and vegetation to guide prescribed fire management strategies. Pre-burn plot data include information on tree, shrub and herbaceous layer vegetation, dead and downed fuels (woody debris, litter and duff), and fuel load, and plot photographs. After burning, data are collected on tree mortality, char and scorch, seedling mortality, fuel loading, and burn severity, and plots are re-photographed. Data are collected 1, 2, 5, 10, and 15 years post-burn.

Data from the standard vegetation and fuels monitoring program, along with other projects that supplement the standard program for Sequoia, Kings Canyon and/or Yosemite, provide the following information:

- dead and down fuel reduction and accumulation
- changes in overstory tree density and species composition by diameter class and condition
- changes in seedling tree density and species composition by height class
- changes in snag density and snag formation/breakdown rates
- changes in shrub density (or cover) and species composition
- changes in cover and species composition of herbaceous vegetation
- changes in ground cover
- changes in species richness
- detection of alien invasive species
- burn severity
- immediate-postburn effects on trees (maximum bark char and crown scorch heights, percent crown scorch)
- mortality of large pines (with and without basal fuel removal mortality) and survival of postfire-regenerated giant sequoia

USGS-BRD staff in Sequoia and Kings Canyon monitor vegetation and fuels in association with a national Fire/Fire Surrogate project (USGS 2004); see USGS fire-related studies, below.

Mechanical Fuels Treatment Monitoring

Mechanical fuels treatments are being implemented in areas associated with development as part of Fire and Fuels Management Plans in Sequoia & Kings Canyon and Yosemite National Parks (National Park Service 2003, National Park Service 2004). Plots are being established to monitor effects of mechanical thinning on overstory trees, seedlings, shrubs (brush), fuels, soils, nonnative plants, and potential fire hazard

Nested frequency plots are being established in Yosemite Valley and Foresta, in sites subject to mechanical treatment and pile burning, to monitor invasion by nonnative plants after treatment. Pre- and post-treatment data are collected; photographs are taken of each plot.

Fire Effects on Wildlife

Many wildlife species are affected by fire, with significant changes to both structure and vegetative composition of habitat. Because rodents are sensitive to habitat change, they make good indicators of wildlife response to fire (Keifer et al. 2003). Changes in rodent populations lead to changes in food availability for raptors and forest carnivores—many of which are either sensitive or of public interest (e.g. fisher, martin, goshawk, etc.). In Sequoia National Park, some limited monitoring of wildlife has focused on areas where prescribed fire is the primary management activity.

In association with the Mineral King Risk Reduction Project in Sequoia (Werner 1995-1998) , long-term monitoring plots were established in a variety of vegetation types where prescribed burning was planned; serendipity surveys were done for common and unique habitats. Long-term monitoring documents long-term changes in rodent populations and habitat following fire under known conditions. Serendipity surveys inventory rodent species and relative abundance within both common and unique environments to facilitate large-scale assessment of potential fire effects.

USGS-BRD staff in Sequoia and Kings Canyon have monitored wildlife species in association with a national Fire/Fire Surrogate project (USGS 2004); see USGS fire-related studies below.

Fire Effects on Water

The effects of fire on water quantity and quality and sediment transport are second order fire effects that have important ecosystem consequences (Keifer et al. 2003). In Sequoia National Park, stream flow and water chemistry monitoring has focused on specific watersheds where prescribed fire is the primary management activity. The objectives of this monitoring were to:

- Evaluate changes in hydrology following prescribed fire by measuring pre-fire and post-fire continuous stream discharge.
- Document changes in hydrochemistry by quantifying solute inputs using wet deposition data from the National Acid Deposition Program (NADP) and California Air Resources Board (CARB) collection sites and solute exports using stream discharge and periodic chemical samples.

A pilot study in the paired mixed-conifer Log Meadow and Tharp's watersheds examined the effects of a single fire on a small (<50 ha), low gradient watershed. This study took advantage of a watershed monitoring program initiated in 1982 (USGS 2000; see Section 1.5.1.5) to study forest demography, atmospheric deposition and watershed processes. Tharp's Creek watershed was prescribed burned in 1990, and provided an opportunity to study stream chemistry and hydrology pre- and post-burn and to compare these data with the unburned Log Creek watershed.

In contrast, ongoing landscape-scale burning in the East Fork Kaweah watershed provides a unique opportunity to evaluate fire effects on watersheds at two very different scales: large (ca. 20,000 ha) and small (ca. 100 ha). Additional sites were established in 1995 to meet the needs of fire management when a large project in the East Fork of the Kaweah River (originally called the Mineral King Risk Reduction Project) was funded. This project was initiated to determine whether accelerating the application of prescribed fire across an entire watershed was feasible and to document the costs and effects of such a landscape-scale program. Monitoring of hydrology and hydrochemistry of this entire watershed is intended to provide information that may be applicable to other large watersheds.

Hydrology results will be used to determine the influence of landscape scale and geomorphology on watershed response to fire. Hydrochemistry results will determine how fire effects the nitrogen and sulfur cycles in small watersheds, and at what spatial and temporal scale are these effects most pronounced (Keifer et al. 2003, Heard in prep.).

Fire Regimes

One of the primary goals of the Sierra Nevada parks' fire management programs is to restore fire as an ecosystem process across the landscape. As a result, park managers need to both understand underlying baseline processes and be able to measure success of the program's efforts at restoring and maintaining this process (Keifer et al. 2003).

Fire regime can be defined as the interactions–from simple to complex–of a suite of attributes that constitute how fire operates as a process in a particular vegetation type or specific location. Attributes that describe characteristics of a fire regime include: fire return interval (distribution, mean, minimum, maximum), season of occurrence, fire size and pattern, fire type (surface, crown, etc.), fire intensity (quantity of heat produced), and fire severity (level of damage to what is affected by fire).

Important modifiers of these attributes include topographic features such as aspect and elevation, climate, and lag effects of historic biotic events. Taken together, these attributes define fire as a process in a particular location and setting. Ideally, design of a program to monitor restoration and maintenance of fire regimes would include evaluation of all these attributes; however, available information is currently limited by our ability to acquire this knowledge and by associated costs. Due to its landscape-level scope, fire regime monitoring encompasses all fire management activities occurring throughout all areas of the parks, including wildland fires (both fire-use and suppression fires) and prescribed fire.

> Monitoring Goal: Fire regime monitoring provides information to evaluate cumulative accomplishments of a fire management program in restoring and maintaining natural fire regime over time, and across the entire landscape.
>
> Monitoring Objectives: (1) track and evaluate the continued implementation of the restoration of fire into park ecosystems; and (2) determine whether the continued occurrence (maintenance) of fire over the long term, either from natural or human ignition sources, falls within a target range as determined from specific resource objectives.

The Sequoia & Kings Canyon and Yosemite National Parks Fire Ecologists, GIS Specialists, and USGS BRD staffs have worked collaboratively in developing spatial models that allow inventory and monitoring of fire regimes through dendrochronological fire histories, human fire records, vegetation classifications, and other spatial data.

For information on target conditions, sampling design, field measurements/baseline information, timing of monitoring, data analysis, and management implications of monitoring results, see Appendix H and the following references: Caprio and Lineback 1997, Keifer et al. 1999, Caprio and Graber 2000, van Wagtendonk ?, NPS 2003, NPS 2004)

<u>Baseline Fire History and Age-Structure Data</u>

The data described below are utilized in the parks' GIS systems to define historic fire regimes for different forest types and landscape areas, and to prioritize areas for future burning.

Devils Postpile

The SEKI Fire Ecologist is currently conducting a fire history and age structure study in Devils Postpile National Monument using dendroecological analysis of tree-ring samples (Caprio in progress). The information from this study will be used to help formulate a Fire and Fuels Management Plan for the monument.

Sequoia, Kings Canyon and Yosemite

The Laboratory of Tree-Ring Research at the University of Arizona (Swetnam et al. 1992) conducted fire history studies in giant sequoia groves and later, across elevation transects in mixed-confer forests in Sequoia, Kings Canyon, and Yosemite National Parks (Caprio and Swetnam 1995). This work has provided valuable information about variation in fire frequency over time, seasonality of fires, relationships between fire frequency, severity and climate, and differences in fire frequency across elevations.

The SEKI Fire Ecologist has built upon the Swetnam et al. (1992) baseline fire history data by expanding fire history and age structure research to additional watersheds and sites in the parks. Sampling is designed to answer questions about fire regime attributes such as area burned annually and frequency patterns relating to aspect, vegetation type and elevation.

Yosemite

Yosemite is conducting a project under the Joint Fire Science Program to identify natural reference conditions for mixed conifer forests. From this information, prescribed fire managers can develop goals for both process and structure for the park's program to reintroduce fire to altered forests. The project objectives are to: 1) quantitatively describe pre-settlement, settlement, and fire suppression period regimes; 2) identify how fire regimes vary along major environmental and forest compositional gradients; and 3) identify pre-fire suppression forest characteristics (basal area, density, size structure) at plot and landscape scales.

USGS-Western Ecological Research Center Fire Studies in Sierra Nevada Parks

Fire and Fire Surrogate (Jon Keeley, Eric Knapp and Dylan Schwilke, Sequoia and Kings Canyon Field Station)

The Fire and Fire Surrogate study is a network of 13 long-term sites established nationwide to evaluate the ecosystem impacts of different fire hazard reduction treatment in forests that historically experienced short-interval, low- to moderate-severity fire regimes. Fuel reduction treatments being investigated by USGS researchers at Sequoia National Park are early-season and late-season prescribed fire. USGS is cooperating with

National Park Service in this effort (USGS 2004). The experimental design consists of nine plots, with three replications of early-season burn, late-season burn, and control treatments in a completely randomized design. Early season burns were conducted 20 and 27 June 2002; late season burns were conducted 28 September and 17 and 28 October 2001.

Detailed data were collected as follows:

- Vegetation: (1) trees and saplings; (2) shrubs, tree seedlings, and understory species; (3) light environment and gap/patch distribution; (4) seedling demography.
- Fuels and fire: (1) down and dead fuel, duff/litter depth; and (2) fuel moisture and fire behavior.
- Birds and small mammals: (1) diversity, abundance, reproductive success—birds; (2) diversity, abundance, microhabitat—small mammals.
- Soils and forest floor: (1) litter, duff; (2) soil layer macronutrient content; (3) soil biodiversity.
- Invertebrates: (1) bark beetle presence; (2) ground macroarthropod diversity and abundance.
- Pathogens

Fire and Invasive Annual Grasses in Western Ecosystems (Jon Keeley and Tom McGinnis for Kings Canyon National Park; Matt Brooks, Jayne Belnap, and Robert Sanford).

Information from: http://www.werc.usgs.gov/fire/lv/fireandinvasives/index.htm

Annual grasses have invaded a number of shrub and forest ecosystems in western North America and are linked to changes in both ecosystem structure and function. In addition to well documented impacts on native plant diversity, these invasives have the potential for altering fuel structure and fire behavior. Research on ways to prevent invasive annual grass invasions and restore invaded habitats has independently and repeatedly been identified by all land management agencies as a top national research priority.

Study ecosystems include: Great Basin Sagebrush Steppe, Sierra Nevada Yellow Pine Forest and Mojave Desert Scrub.

Objectives:

- Examine interactions between fire, soil, nutrients, and invasive grass productivity over a range of low-nutrient ecosystems currently dominated or threatened by invasive annual grasses in Western North America
- Find common factors driving the fire/annual grass cycle in these ecosystems with the goal of producing generalizations widely applicable beyond the ecosystems under study
- Investigate and document the process by which invasive plant species are inhibited, stimulated, and/or proliferated by fire

- Determine which ecosystems or vegetation types are most susceptible to invasion following fire
- Observe the effects of treatments by which invasive plants can be controlled

A combination of intensive field experiments, extensive field surveys, laboratory experiments, and seedbank analyses are being used to evaluate the interrelationships between fire, soil, nutrient availability and invasive grass dominance. These three components complement each other and will be used to develop a comprehensive model that relates mechanisms of annual grass invasion after fire to field conditions and potential postfire mitigation techniques.

The Sierra Nevada (Kings Canyon) portion of this study (2001-2003) included the following: Pre-fire sampling of soils and plants, nutrient applications, burns in fall and summer, and post-fire soil and plant sampling and monitoring.

Fire and grazing impacts on plant diversity and alien plant invasions in the southern Sierra Nevada (Jon Keeley and Daniel Lubin)

Patterns of native and alien plant diversity in response to disturbance were examined along an elevational gradient in blue oak savanna, chaparral, and coniferous forests in the southern Sierra Nevada. Total species richness, alien invasive species richness, and alien invasive cover declined with elevation (scale ranging from 1 to 1000 m2). Community diversity did not inhibit alien invasive invasion in this study.

Aquatic Monitoring

For detailed information on monitoring of aquatic resources in and around SIEN, please see Appendix D.

Hydrology

Devils Postpile

Throughout 1994, the National Park Service and California Department of Fish and Game monitored stream flow along the Middle Fork of the San Joaquin River as part of a fishery and riparian resources assessment project (Rowan et al. 1996). Monitoring (opportunistic) continued for several more years.

Sequoia and Kings Canyon

There are twelve active gaging stations located in or near the parks' boundary; period of record range from eight to 54 years. The U. S. Geological Survey in conjunction with Southern California Edison, monitors streamflow on the lower Marble, Middle, East and Main Forks of the Kaweah River. The National Park Service and UC Santa Barbara monitor streamflow at eight small, research watersheds located throughout the Kaweah watershed. In addition, water quantity data exist for 24 historic gaging stations; stream flow records range from three to 71 years.

Yosemite

There are 21 active gaging stations located in or near the parks' boundary.

The site with the longest period of water quality monitoring (1967-present) in the Sierra Nevada Network is the Merced River at Happy Isles, located in upper Yosemite Valley. Happy Isles is maintained by the US Geological Survey as part of the Hydrologic Benchmark Network. Recently, the USGS installed a chemical analyzer that records continuous nitrate plus nitrite concentrations. The Happy Isles watershed area is 46,900 ha and the elevation ranges from 1,224 to 3,997 m. Like most Sierra streams, stream water at Happy Isles is dilute with a low buffering capacity; sp. conductance ranges from 3.0 to 65 uS/cm and alkalinity ranges from 20 to 360 meq/L (Mast and Clow 2000). Mast and Clow (2000) analyzed Happy Isles data set for long-term trends using water quality data from 1968-1995. Using the seasonal Kendall test, they detected statistically significant trends (α = .01) for pH and sulfate concentrations. They attributed the increasing trend in pH to inconsistencies between instruments or personnel through time as opposed to environmental factors. The decrease in sulfate was partially explained by variations in streamflow; however, interpretation was complicated by coinciding changes in analytical methods during the study period. In addition to long-term monitoring data, there have been numerous additional research studies associated with Happy Isles (Hoffman et al. 1976, Clow et al. 1996, Brown and Short 1999).

The San Francisco Public Utilities Commision (SFPUC) has collected monthly surface water samples from Hetch Hetchy Reservoir since the 1950s. Currently the reservoir is sampled for alkalinity, hardness, pH, turbidity, temperature, specific conductance, chloride, and coliform bacteria (total and fecal). Limnology profiles are collected approximately once per month near O'Shaughnessy Dam. On occasion, SFPUC conducts additional sampling in the upper watershed. Water quality data are summarized in Sanitary Surveys every five years. Results indicate that water quality in Hetch Hetchy is of high quality and in full compliance with state and federal standards (San Francisco Water Team and CH2M HILL Inc. 1995, San Francisco Public Utilities Commission 1999).

The California Water Resources Control Board collected water quality data from 1973 to 1986 on the Tuolumne River near Tuolumne Meadows and from 1966 through 1989 on the Merced River near Briceburg.

The Yosemite Facilities Management Division monitors water quality for drinking water sources and wastewater discharge effluent. Detailed source location data are not widely published for security reasons; however, more information can be obtained from this division. In general, front country drinking water sources are monitored for total coliform, escherichia coli (most probable number/100ml), general minerals, general physical and inorganic chemical parameters. Monitoring frequency is dependent on the classification of the water system and the source (National Park Service 1999).

A Yosemite hydroclimate network was developed as inter-agency effort over the last four years to further our understanding of meteorological, hydrological, and biogeochemical processes, especially how they are affected by a climate change (DiLeo et al. 2003). Thirty-five new gaging stations were installed in the upper Merced and Tuolumne watersheds along with numerous water quality sampling locations.

The National Park Service monitors water quality since 2004 as part of the Visitor Experience and Resource Protection Program (VERP) (Yosemite National Park 2004). Water quality is one of eleven indicators used to monitor the impacts of visitor use along the Merced Wild and Scenic River corridor. The parameters include fecal coliform, total nitrogen, total phosphorus, and petroleum hydrocarbons.

See also, vegetation monitoring projects, supra, that include hydrology monitoring.

Water Chemistry

See Appendix D.

Geologic and Physical Resources Monitoring

Geology

Need map information.

Geomorphology

Yosemite National Park

In 1989, Madej need more contact info- especially agency affiliation initiated long-term monitoring of the geomorphology of the Merced River and Tenaya Creek in Yosemite Valley. Nineteen cross-sections were established where elevational profiles are measured once every three to five years. Since that time, Yosemite National Park has continued to survey these sites and has increased monitoring to 61 cross-sections (SIEN data documentation database, Project # ___).

Cave Resources

Sequoia and Kings Canyon National Parks

Sequoia and Kings Canyon National Parks monitor the number of visitors to Crystal, Hurricane Crawl, Soldiers and Lilburn Caves. Managers monitor visitation using permits, trip reports, and cave registers in order to track and manage underground visits. The Cave Visitation History data set begins in 1962 and continues through present day.

Sequoia and Kings Canyon National Parks and the Sequoia Natural History Association have been monitoring radon concentrations in park caves since 1977. Although radon monitoring data exist for numerous park caves, the majority of the data are from Crystal Cave, which is monitored annually. The Sequoia Natural History Association offers guided tours of the Crystal Cave throughout the summer months. The radon monitoring is conducted to protect their employees' health.

UC Santa Cruz monitored surface and cave temperature and relative humidity from 2000 to 2004. The purpose was to evaluate cave temperatures with a high degree of accuracy over time. Monitoring was conducted in Crystal, Kaweah, Clough, and Palmer caves.

Soils

Sequoia and Kings Canyon National Parks

The U. S. Geological Survey is monitoring soil nutrient dynamics as a component of the Fire and Fire Surrogate Study. This is a nationwide study evaluating ecosystem impacts of different fuel reduction treatments. USGS researchers at Sequoia National Park are comparing the effects between early season and late season prescribed fire. From 2001 to 2004, USGS researchers in conjunction with Colorado State University are analyzing soil and forest floor samples for carbon and nitrogen content, available nitrogen, soil pH, cation exchange capacity, soil organic matter, calcium, magnesium and potassium content, and soil enzyme activity.

See also, Tharp's and Log soils'research pre- and post-Tharp's burn (Chorover et al.).

Monitoring Conducted by Other Agencies on Adjacent Lands

USFS Sierra Nevada Framework monitoring projects: The USFS is currently in its third year (circa 2005) of implementing peer-reviewed monitoring protocols (USFS 2004) on national forest lands Sierra Nevada-wide. The protocols of potential interest to SIEN parks include: amphibians (Yosemite toad and mountain yellow-legged frog), meadows (status and change), forest carnivores, vegetation communities and landscape-level fire mapping and monitoring. Unfortunately, many of the USDA Sierra Nevada Forest Service monitoring projects have lost funding and are no longer being monitored (though some protocols may be useful if they have similar objectives).

From an initial monitoring plan for California Spotted Owl (circa 1995-1996), the Sierra Nevada USDA Forest Service monitoring program began a broader, more strategic approach (circa 1997). In 1997, a Sierran Province Assessment and Monitoring (SPAM) team was formed and began a 5-year planning phase (funding level of $1 million per year). This planning team consisted of 20 biologists. However, as of 2005, many of the individual monitoring programs that were developed (discussed below) have lost funding.

Similar to SIEN's Phase I planning efforts, SPAM's review and assessment of land management plans on Sierra Nevada forests revealed that not much systematic monitoring was occurring. In addition, no other regional-level ecosystem monitoring programs were in place in other USFS regions.

Over a span of 5 years (through 2001), SPAM worked to create a cost-effective, science-based strategy for monitoring, and developed an Ecosystem Process Model (Manley et al. 2000). Two subsequent initiatives affected this planning endeavor: Sierra Nevada

Ecosystem Project (SNEP) completed in 1996 and the Sierra Nevada Framework for Conservation and Collaboration. The SPAM team was commissioned to work on the Framework EIS in 1999.

The Framework identified 5 key “problem” areas that then became the focus of the monitoring team and their planning efforts.

1) Old forest ecosystems

2) Lower westside hardwood forests

3) Fire and fuels

4) Noxious weeds

5) Aquatic, riparian and meadow systems

In 2001, the Sierra Nevada Forest Plan Amendment was completed; a description of monitoring issues, questions and needs is contained therein (www.fs.fed.us/r5/snfpa).In addition, the monitoring team received $3 million. A lead team of 10 biologists, with 60 temporary biologists, prepared 40 “study plans” and used a ranking process to prioritize monitoring topics. Such monitoring “topics” could be considered similar to SIEN’s vital signs. However, the monitoring objectives, questions, and metrics–and therefore study design and sampling protocols–could be very different from SIEN parks’ needs and objectives.

From these 40 topics, the following seven were implemented (pilot testing) in 2001. Some were never funded, and, as of 2005, several others lost funding (noted in parentheses):

1) Carnivore (main focus on fisher and marten)

2) Amphibians (Yosemite toad, mountain yellow-legged frog)

3) Multi-species

4) Meadows (last year of funding was 2004)

5) Fire and fuels (last year of funding was 2004; some work continuing)

6) Noxious weeds (never funded)

7) Old forest and lower westside hardwoods (last year of funding was 2004)

Two air quality–and one lake chemistry–topics were identified in an additional air quality study plan, but no funding was available until circa 2003:

8) Ozone injury to pines (last year of funding was 2004)

9) Smoke from prescribed burns

10) Lake acidification (from air pollution)(last year of funding was 2004)

Sierra Nevada USFS short-term monitoring goals were to have some (1) "condition" information in 5 years, and (2) "trend" information in 10 years.

SIEN will evaluate USDA Forest Service's monitoring objectives and protocols, for the topics noted above, to see where collaboration is feasible and prudent for those projects still being funded (e.g. amphibians), or to see where protocols can be used or adapted (e.g. meadows) as we embark on protocol development and implementation. In addition, SIEN will investigate the newly-available "Multiple Species Inventory and Monitoring" (MSIM) protocol which has been designed to collect statistically valid information on a wide range of plant and animal species over a broad area and at a minimal cost. The MSIM is apparently a robust monitoring protocol, with repeated sampling, that obtains basic presence and distribution data for a large number of plant and animal species and condition data for their habitats.

<u>USFS Forest Inventory & Assessment and Forest Health Monitoring Plots</u>: These plots, installed throughout the Sierra Nevada (including several in Sequoia, Kings Canyon and Yosemite National Parks), could be of value for a number of potential indicators of interest (forest community species composition and structure, lichens, and ozone effects on vegetation).

<u>USGS Western Ecological Research Center</u>: While most of the research and monitoring done by the USGS Sequoia & Kings Canyon and Yosemite Field Stations is accounted for in the in-park monitoring list above, we want to emphasize that the USGS projects in our parks are an integral part of NPS resource management information and decision-making. The USGS Global Change Research program (including forest demography and other projects), the numerous fire-related research and monitoring projects and the invasive species research projects done by the Sierra Nevada USGS field stations provide valuable information to inform development of additional long-term monitoring.

<u>Focal Species Monitoring (USFS and CDFG)</u>: Some of the monitoring efforts of USFS and/or CDFG on focal species or species of concern, such as Sierra bighorn sheep, Peregrine Falcon, neotropical migrants and sensitive plants may be of interest to the Sierra Nevada Network, if adequate protocols are in place and the network chooses to monitor any of these groups of organisms.

Monitoring conducted by outside agencies and organizations (Table below) that currently have the most potential value to the SIEN vital signs monitoring plan are summarized below.

Summary of natural resources monitoring conducted outside SIEN park boundaries.

MONITORING OR STUDY	NOTES
United States Department of Agriculture, U.S. Forest Service - Sierra Nevada Framework	
California Spotted Owl	response to fuels treatment and habitat modification; demographic studies
Pacific fisher and other forest carnivores	status and change; effects of fire and fuels treatments; habitat relationships; reproduction and mortality
Yosemite toad	direct and indirect effects of various livestock grazing practices; habitat requirements
willow flycatcher	conservation strategy; management planning
meadows	status and change; distribution of animal species that use meadow ecosystems
Kings River project	small mammals, forest birds, spotted owls; evaluate response of forests to uneven-aged silviculture and prescribed fire
soil productivity	status and change
air quality	smoke monitoring; ozone
vegetation communities	status of the quantity and quality of conifer and hardwood forest ecosystems and how they are changing over time
landscape-level fire mapping	fire size, fire severity
amphibians	Yosemite toad and mountain yellow-legged frog
United States Department of Agriculture, U.S. Forest Service Inyo National Forest	
air quality	visibility
soil productivity	porosity, cover, organic matter, etc. monitored in a random sample of prescribed burn areas, fuelwood sale areas, site prep areas; compaction is monitored in specified grazing areas
northern goshawk	annual surveys of all known nest sites within areas managed for timber; occupancy and reproductive success
peregrine falcon	implementing USFWS recovery plan; nesting and reproductive success
Sierra Nevada and Nelson mountain sheep (with California Department of Fish and Game)	annual counts; habitat evaluations
wintering bald eagle	implementing USFWS recovery plan
pine marten	camera detection techniques to determine species presence
mule deer (with California Department of Fish and Game)	annual herd census and demographic assessments

MONITORING OR STUDY	NOTES
songbirds	Point Reyes Bird Observatory monitors abundance, richness, diversity, breeding status survival, productivity, and parasitism rates in riparian habitats
Threatened & Endangered fish (with California Department of Fish and Game)	Owens tui chub, Paiute cutthroat, Lahontan cutthroat trout
resident trout	habitat condition
riparian vegetation	
sensitive plants	population trends
floristic analysis of San Joaquin Roadless Area	inventory
snags and downed logs	quantity and distribution
ecological surveys of Research Natural Areas (Connie Millar, USFS, PSW Research Station)	vegetation mapping, community descriptions, plant and animal species lists, cursory geology and soils, impacts, etc
meadow and forest conditions (Connie Millar, USFS, PSW Research Station)	tree invasion in meadows and in shrinking permanent snowfields; periodicity of krummholz whitebark pine vertical leader release; branch length extension in krummholz whitebark pine; quantitative vegetation plots; climate reconstruction and dating of Glass Ck vent; genetic and dendrochronological work on krummholz whitebark pine; dendrochronological work on limber pine
United States Geological Survey	
volcanic parameters for Long Valley Caldera and Mono Craters Region	seismicity, deformation, water-well levels, CO_2 gas concentrations and flux rates; geochemistry; hydrology
Sierra Nevada Aquatic Research Laboratory, University of California, Santa Barbara	
ecology of Mono Lake	physical-limnology modeling and monitoring of brine shrimp and alkali fly populations
Sierran snowpack	snowpack properties and snowmelt runoff
aquatic biology	effects of impacts of livestock grazing on stream ecology and effects of nonnative trout on Sierra Nevada lake ecosystems
White Mountain Research Station, University of California	
	wide range of projects - see Appendix for details
The Nature Conservancy	
	early stages of developing studies and monitoring for an area west of Sequoia
California Department of Fish and Game (The Resources Agency)	
montane meadows	monitoring and predictive modeling for all Sierran meadows
mountain lakes and amphibians	

MONITORING OR STUDY	NOTES
Sierra Nevada bighorn sheep/mountain lion	

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